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VARIATIONS IN THE VITELLARIA AND VITELLINE
DUCTS OF THREE DISTOMES OF THE GENUS
OPISTHORCHIS

BY F. D. BARKER

WITH TWO PLATES

In an investigation of the variations in the various organs of *Opisthorchis pseudofelineus* Ward, one is particularly impressed with the interesting and striking variations which occur in the vitellaria and vitelline ducts of this species. These variations are described in the following paper and for the purpose of comparison, the results of the work of two other investigators, Weski (1900) and Mühling (1896), are also given. Weski and Mühling have worked out the variations in the vitellaria and vitelline ducts of two species of the genus *Opisthorchis*, closely related to *O. pseudofelineus*.

Ward (1895: 241) describes the vitellaria of *Opisthorchis pseudofelineus* as follows: "The glands begin about half as far behind the acetabulum as that is from the oral sucker, and extend to the middle of the space between the two testes, or even sometimes as far as the anterior edge of the posterior testis. One break in the line of acini may always be recognized as most prominent; it is located just opposite the ovary on each side, and is in length more or less equal to the diameter of the ovary. This space divides the vitellarium into two portions, which may be distinguished as antovarial and postovarial. While it is in some cases possible to distinguish in the antovarial portion groups of acini, they seem to be usually rather indistinct, or at least very unequal in size, as if adjacent groups had become confluent by the growth of interlying acini. The postovarial portion, however, is usually distinctly divided into two or three groups of acini, though even these may be obliterated. In two or three cases a small group of acini was found, on one side only, in this intermediate space opposite the ovary, and was

clearly separated from both antovarial and postovarial portions by a small space. Corresponding to the two portions of the gland, one finds on each side two ducts which, extending obliquely toward the ovary, from a short distance before and behind it, form a 'Y' or 'V' according as they meet before or not until after reaching the ovary. These ducts on either side of the ovary form one of the most characteristic appearances of the specimen." Stiles (1904: 32) gives the following description of these glands: "Vitellaria divided each side into an antovarial portion with about five acini and a postovarial portion with two or three acini, each portion provided with its own vitelloduct; the antovarial portion extends from the ovary cephalad to about the boundary between the anterior and equatorial thirds of the body; the postovarial portion extends caudad from the ovary to about the anterior plane of the posterior testicle."

Looss (1899: 675) considers the vitellaria the most constant specific character, not only in the genus *Opisthorchis*, but also in all distomes, and holds that the form and size of the other genital organs are of much less value as specific characters. It is of great importance to determine in specific cases just how far this view is correct.

The results of the examination of more than one hundred specimens of *Opisthorchis pseudofelineus* show that there is considerable variation even in the vitellaria, and make a few slight changes in the descriptions given by Ward and Stiles seem advisable.

The extent of the vitellaria, caudad and cephalad, is one of the most important characters of the vitellaria, if not the most important, and is of special significance as a specific character. Because of the specific value attributed to the extent of the vitellaria, we should expect to find their limits rather definite and constant; on the contrary, we find that they vary considerably. The vitellaria never extend to the acetabulum, but their position posterior to the posterior margin of the acetabulum on the right side varies from 0.3 mm. to 4.5 mm., the mode being 1.10 mm., with a frequency of 23 or 23 per cent. On the left side the position varies from 0.3 mm. to 3.7 mm., the mode being 0.7 mm., with a frequency of 18 or 18 per cent. The class 1.1 mm. had a frequency of 12, the class 1.3 mm. of 14, and the class 1.5 mm. of 15. The modes for the right and left sides show that the vitellaria extend farther cephalad

on the left than on the right side. In individual specimens the extent of the vitellaria cephalad may be equal on the right and left sides or greater on the right than on the left side.

A comparison of the length of the anterior portion of the body (from the anterior end to the ovary) with the position of the vitellaria, posterior to the ventral sucker, shows that the extent of the vitellaria cephalad varies independently and is not affected by the degree of contraction of the anterior portion of the body.

In three living specimens which were observed, those regions of the worm anterior to the acetabulum and posterior to the ovary were found to be most distensible and consequently to vary most in length with the contraction and expansion of the worm. In view of these facts Ward's (1895) description of the anterior limits of the vitellaria, "the glands begin about half as far behind the acetabulum as that is from the oral sucker," and Stiles' (1904) description, "the antovarial portion extends from the ovary cephalad to about the boundary between the anterior and equatorial thirds of the body," are not sufficiently definite, since the relative position of the acetabulum and the oral sucker and the boundary between the anterior and equatorial thirds of the body will vary with the contraction and expansion of the anterior region of the body. The limits of the vitellaria cephalad, though they vary with reference to the posterior margin of the acetabulum, are more definite if given in millimeters, inasmuch as that portion of the body posterior to the acetabulum is not so much affected by the state of contraction or expansion of the anterior region as that portion of the body anterior to the acetabulum.

It is convenient to state the extent of the postovarial portion of the vitellaria with reference to the testes and inasmuch as the relative position of these organs is fairly constant, such a designation is sufficiently definite.

The extent of the vitellaria caudad varies from the anterior margin of the anterior testis to a plane 0.07 mm. to 0.30 mm. posterior to the posterior testis, the mode being the anterior margin of the posterior testis, with a frequency of 28 or 28 per cent. for the right side.

On the left side the extremes were found to be a plane 0.16 mm. anterior to the anterior testis and a plane 0.07 mm. to 0.25 mm. posterior to the posterior testis, the mode being the anterior margin

of the posterior testis, with a frequency of 22 or 22 per cent. The planes and margins used in designating the limits of the vitellaria are the transverse planes of the body of the worm.

The extent of the vitellaria caudad is, in the aggregate, approximately the same for the right and left sides. The vitellaria extended to or beyond the anterior margin of the posterior testis in seventy-one specimens on the left side and in seventy specimens on the right side. In 12 per cent. of the specimens the vitellaria extended to the posterior margin of the posterior testis on the left side and in 9 per cent. on the right side. In 8 per cent. the vitellaria extended from 0.07 mm. to 0.25 mm. beyond the posterior testis on the left side and in 7 per cent. from 0.07 mm. to 0.30 mm. beyond it on the right side. The extent of the vitellaria may be equal on both sides, as was the case in 27 per cent. of the specimens, or the extent may be greater on the left side than on the right side, as found in 38 per cent., or the extent may be greater on the right than on the left side, as found in 38 per cent.

The posterior third of the body was found to be the most distensible in living specimens and consequently the position of the posterior testis and the posterior limits of the vitellaria vary greatly with reference to the posterior margin of the worm, but the relative position of the testes and the limits of the vitellaria remain very constant.

The occurrence, extent, and position of the break between the antovarial and postovarial portions of the vitellaria were found to vary considerably. On the right side, in two specimens, no break occurred, the last group of the antovarial portion and the first group of the postovarial portion being in contact, but not connected by a duct. This complete obliteration of the break is evidently not due to the contraction of the worm, for in both of these specimens there was a distinct break on the opposite side (pl. VIII, fig. 11). In ten specimens a distinct break occurred, but the two regions were connected by a vitelline duct similar to the ducts which connect the groups of either region (pl. VIII, figs. 4, 7, 9).

On the left side the antovarial and postovarial regions were in contact in one specimen and connected by a vitelline duct in four specimens. The extent of the break between the postovarial and the antovarial portions was found to vary from 0.08 mm. to 1.3 mm. on the right side, 0.2 mm. being the mode, with a frequency of 33

or 33 per cent. On the left side the extremes were 0.06 mm. and 1.9 mm., the mode being 0.2 mm., with a frequency of 26 or 26 per cent. In nine specimens the break was less than 0.1 mm., this being less than the average break between the groups of either the antovarial or the postovarial region. The middle third of the body is least affected by the contraction and distension of the worm. A comparison of the extent of this break with the length of the worm shows that the extent of the break is not affected by the degree of contraction of the worm, but that it varies independently.

The position of this break in relation to the ovary varies somewhat, but is more constant than the characters already mentioned. The extremes for the position of the break were found to be a position more or less anterior to the anterior margin of the ovary,—in one specimen (pl. VIII, fig. 3) far anterior,—and a position more or less posterior to the posterior margin of the ovary, with all gradations between these extremes. The mode was a position opposite the middle of the ovary, with a frequency of 49 per cent. on the right side and 55 per cent. on the left side.

The distinctness and consequently the number and size of groups in the antovarial and postovarial region varies considerably. In some specimens the groups appear to be fused and form one or more continuous masses. As Ward (1894) suggests, this is probably due to a confluence of close-lying groups or the growth of intermediate groups. The groups are more distinct and the number more definite in the postovarial regions than in the antovarial regions.

In the specimens in which the groups were definite the number varied from one to six groups in the right antovarial region, five groups being the mode, with a frequency of 61 per cent., and either two or three groups in the right postovarial region, there being an equal number having the two groups and the three groups. The combination of five groups in the antovarial and three groups in the postovarial region was found to be the most common, 30 per cent. having this combination.

On the left side the number of groups varied from one to six in the antovarial region, 67 per cent. having five groups. In the postovarial region the number of groups was either two or three, 58 per cent. having three groups. For the left side the most frequent combination was found to be five groups in the antovarial and three groups in the postovarial region, 43 per cent. having this

combination. The arrangement of groups is seen to be more constant on the left than on the right side.

In eight specimens a single group, which Ward (1894) mentions, was found in the space between the antovarial and postovarial portions of the vitellaria and distinctly separated from both portions by a small space. This intermediate group occurred in two specimens on the right side and in six specimens on the left, never occurring on both right and left sides in the same specimen and was in every case the sixth group counting from the anterior (pl. VIII, figs. 5, 8).

In one specimen there were eight distinct and normal groups, three groups in the postovarial and five groups in the antovarial region, on the left side, and only five distinct and normal groups, two groups in the postovarial and three groups in the antovarial region, on the right side. The two anterior groups of the antovarial region on the right side were vestigial; the first group was simply a mass of yolk cells, with no distinct acini; the second group consisted of a few acini arranged along the longitudinal duct. The longitudinal duct was distinct and normal (pl. IX, fig. 4).

In another specimen there were on the right side four or six groups, two or three groups (the last group probably being two groups lying very close together) in the postovarial region and two or three groups in the antovarial region, and only four groups on the left, three groups in the postovarial region and one group in the antovarial. The longitudinal duct, filled at intervals along its course with yolk cells, extended as far cephalad as the gland on the right side, but the groups of acini were entirely lacking (pl. IX, fig. 2).

In one specimen the third group of the postovarial region on the left side was vestigial, the longitudinal duct alone remaining.

One of the most characteristic features of this species is found in the vitelline ducts, which extend obliquely toward the ovary from each portion of the vitellaria. These ducts form a "V" or a "Y" as they meet after or before reaching the ovary. These types combine in several ways to form four distinct classes. First, a "Y" type of duct on both the right and left sides (pl. VIII, fig. 1); second, a "V" type of duct on both sides (pl. VIII, fig. 2); third, a "V" type of duct on the left side and a "Y" type on the right side (pl. VIII, fig. 4); fourth, a "V" type on the right and

a "Y" type of duct on the left side (pl. VIII, fig. 6). The following table shows the occurrence of these various classes in one hundred specimens:

Class	Number of Specimens
"V" type right and "V" type left.....	42
"Y" type right and "Y" type left.....	22
"V" type right and "Y" type left.....	18
"Y" type right and "V" type left.....	18

The study of these ducts revealed some striking variations. In those specimens in which there was an intermediate group between the antovarial and postovarial regions of the vitellaria this group receives a branch vitelline duct from the principal antovarial duct in four specimens (pl. VIII, figs. 2, 5), and from the postovarial duct in two specimens. In one specimen the vitelline ducts were three in number, of which the median duct passed to this intermediate group (pl. VIII, fig. 8).

In three specimens a short branch duct passed caudad from the right antovarial vitelline duct, immediately after it left the group, to the first group of the postovarial region (pl. VIII, fig. 6). A slight shifting in the position of the origin of this branch duct would bring about the condition, which has already been mentioned, *viz.*, the connection by a duct of the antovarial and postovarial regions of the vitellaria (pl. VIII, fig. 9).

In one specimen the postovarial duct connected with this intermediate duct instead of passing backward to the first postovarial group (pl. VIII, fig. 7). In one specimen an accessory duct was found which connected the antovarial and postovarial ducts (pl. VIII, fig. 10). In four specimens, only one duct was found on one side, in two cases on the right side and in two cases on the left side. This condition is possibly due to an extreme variation of the "Y" type of duct, in which the arms of the "Y" form right angles, instead of acute angles, with the stem of the "Y," in this way producing a "T" type of duct (pl. VIII, figs. 3, 11, 12). One finds all possible degrees of variation from one extreme, the "T" type of duct passing through the "Y" type, to the "V" type, the other extreme (pl. VIII, figs. 12, 13, 14, 15).

In summarizing the above discussion we find, for *O. pseudo-felineus*, that the position of the break between the antovarial and the postovarial regions of the vitellaria is one of the most constant

characters; that the extent of the vitellaria caudad is extremely variable, and therefore a characteristic which in itself is of very little specific value; that the number of groups in each region of the vitellaria is fairly constant, five groups in the antovarial and three groups in the postovarial region, though variations may occur through the fusion of groups and the appearance of accessory groups; that the "V" type of vitelline duct predominates.

It is of value to compare with the variations noted the variations in the vitellaria of two other species of the genus *Opisthorchis*, which are closely related to *Opisthorchis pseudofelineus* and closely resemble it in appearance and in the arrangement of their various organs. Mühling (1896: 260) describes the vitellaria and ducts of *Opisthorchis felineus* Riv. as follows: "The vitellaria lie in the middle third of the body, lateral to the intestinal crura and consist generally of eight groups of small transversely arranged acini. One rarely finds nine or seven such groups. The acini (groups) are connected by a longitudinal duct. The paired vitelline ducts generally arise from the longitudinal duct, which connects the last two groups of the vitellaria, and pass obliquely backward to the ovary, uniting in the median line to form a single short duct" (pl. ix, fig. 3).

Mühling (1896: 261) examined sixty specimens of *Opisthorchis felineus* and found the following variations in the vitellaria and ducts. In fifty-four cases, or 90 per cent. of the number examined, the vitellaria were composed of eight acini (groups); in one specimen there were nine acini (groups) on the right side and in another specimen there were six acini (groups) on each side; in five specimens there were six acini on each side, but in one of these specimens the first acinus was lacking on one side, but the longitudinal duct, filled with yolk cells, was still present.

In 88 per cent. of the specimens the vitelline duct arose from the longitudinal duct connecting the last two groups; in nine cases the vitelline duct arose from the longitudinal duct which connects the next to the last groups, namely, the sixth and seventh; in four cases the vitelline duct arose from the sixth group; and in one specimen the two vitelline ducts, one of which arose from the connecting duct between the last two groups, the other duct arising from the last group, coalesced before passing to the ovary.

In comparing the vitellaria of *Opisthorchis pseudofelineus* and

Opisthorchis felineus, one notes that there is considerable difference in the general appearance of the glands. These differences would eliminate certain variations in the one that are found in the other. On the whole, there seems to be less variation in the glands and ducts of *Opisthorchis felineus* than in *Opisthorchis pseudofelineus*.

In certain features the vitellaria of *Opisthorchis lancea* Dies. are very similar to the glands of *Opisthorchis pseudofelineus*. Weski (1900: 580) describes the glands of *Opisthorchis lancea* as follows: "The paired vitellaria lie on either side, lateral to the intestinal crura, and extend from a plane back of the acetabulum, equal to the diameter of the acetabulum, to the end of the intestinal crura. They are composed of small, transversely placed acini, which appear in more or less distinct groups. On each side there are eight groups, which are divided into two distinct regions, an anterior and a posterior region, by a large break between the fourth and fifth groups. The groups of each half are connected by a median canal, the union of which forms the transverse vitelline duct" (pl. ix, fig. 1).

Weski (1900) examined a large number of specimens (400) of *Opisthorchis lancea* Dies. and reports the following variations in the vitellaria and ducts.

In 158 cases there were two regions, each region having four groups, or eight groups in all, on the right side. In 116 cases these same conditions were found on the left side. In 22 cases the groups were distinct, but there was no break between the anterior and posterior regions on the right side, and this same condition was found in four cases on the left side. In 119 cases the groups coalesced on the right side and in 35 cases on the left side and no break occurred between regions on either side. In 71 cases the groups coalesced on the right side but the break between regions was distinct; this condition occurred on the left side in 245 cases. The break occurred between the fifth and sixth groups instead of between the fourth and fifth in 21 cases. In nine cases there were only seven groups on the right side, the break occurring between the fourth and fifth groups. Weski also states that there is generally a difference in the extent of the caudad half of the glands on the right and left sides, the caudal half of the right gland generally being the shorter.

The extent and similarity in the variations of the vitellaria and

ducts of *Opisthorchis pseudofelineus* and *Opisthorchis lancea* are very striking, this condition probably being due to the great similarity in the general appearance and normal condition of these organs in the two species. One does not find such similarity in the variations of the position of the other genital organs of these two species; this will be fully discussed in a paper, nearly ready for publication, on "Variations in the position of the genital organs of trematodes.

I desire here to acknowledge my indebtedness and appreciation to Professor Henry B. Ward, the Director of the Zoological Laboratory, the University of Nebraska, at whose suggestion I began this investigation and with whose helpful co-operation I have been able to complete it.

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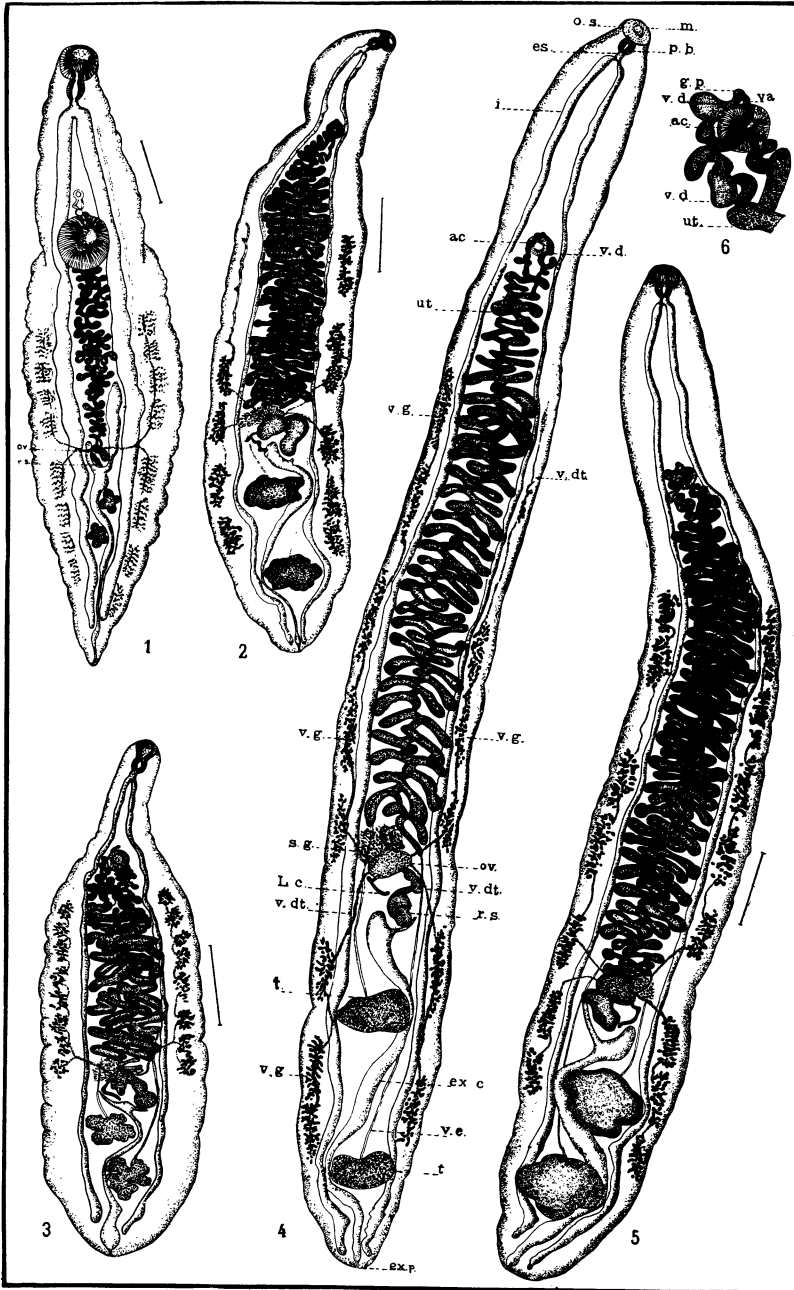
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PLATE VIII



EXPLANATION OF PLATES

ABBREVIATIONS

<i>ac.</i>	Acetabulum.	<i>p. b.</i>	Pharynx.
<i>es.</i>	Esophagus.	<i>r. s.</i>	Receptaculum seminis.
<i>ex. c.</i>	Excretory canal.	<i>s. g.</i>	Shell gland.
<i>ex. p.</i>	Excretory pore.	<i>t.</i>	Testis.
<i>g. p.</i>	Genital pore.	<i>ut.</i>	Uterus.
<i>i.</i>	Intestine.	<i>va.</i>	Vagina.
<i>L. c.</i>	Laurer's canal.	<i>v. d.</i>	Vas deferens.
<i>m.</i>	Mouth.	<i>v. dt.</i>	Vitelline duct.
<i>o. s.</i>	Oral sucker.	<i>v. e.</i>	Vas efferens.
<i>ov.</i>	Ovary.	<i>v. g.</i>	Vitelline gland.

Plate VIII

Variations in the vitelline glands and ducts of *Opisthorchis pseudofelineus* Ward. Only those groups of the vitellaria which are near the ovary are shown, the underlined figures indicating the number of the group, counting caudad in the antovarial region and cephalad in the postovarial region.

Fig. 1. "Y" type of vitelline ducts, ventral view. $\times 14$.

Fig. 2. "V" type of vitelline ducts, ventral view. $\times 21$.

Fig. 3. Variation in position of break between the regions of the vitellarium, ventral view. $\times 14$.

Fig. 4. "V"—"Y" type of vitelline ducts, dorsal view. $\times 14$.

Fig. 5. Median group of vitellarium, opposite ovary, dorsal view; 2, 3, 5, 6, number of vitelline glands. $\times 14$.

Fig. 6. Accessory vitelline duct, dorsal view. $\times 14$.

Fig. 7. Regions of vitellarium connected by duct, ventral view. $\times 14$.

Fig. 8. Median group of vitellarium opposite ovary, dorsal view. $\times 14$.

Fig. 9. Regions of vitellarium connected, dorsal view. $\times 14$.

Fig. 10. Accessory vitelline duct, dorsal view. $\times 14$.

Fig. 11. Single vitelline duct on left side, ventral view. $\times 14$.

Fig. 12. "T" type of vitelline duct, dorsal view. $\times 14$.

Fig. 13. "Y" type of duct, dorsal view. $\times 14$.

Fig. 14. "V" type of duct, dorsal view. $\times 14$.

Fig. 15. "V" type of duct, dorsal view. $\times 14$.

Plate IX

- Fig. 1. *Opisthorchis lancea* Dies., ventral view. After Weski, 1900: 582. $\times 10$.
- Fig. 2. *Opisthorchis pseudofelineus* Ward, dorsal view, showing degenerate vitelline glands. $\times 11$.
- Fig. 3. *Opisthorchis felineus* Riv., ventral view. $\times 11$.
- Fig. 4. *Opisthorchis pseudofelineus* Ward, dorsal view, showing degenerate vitelline glands. $\times 11$.
- Fig. 5. *Opisthorchis pseudofelineus* Ward, ventral view. $\times 11$.
- Fig. 6. *Opisthorchis pseudofelineus* Ward, acetabulum and genital pore. $\times 30$.

PLATE IX

